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## Crocodylian diversity peak and extinction in the late Cenozoic of the northern Neotropics

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(Article begins on next page)

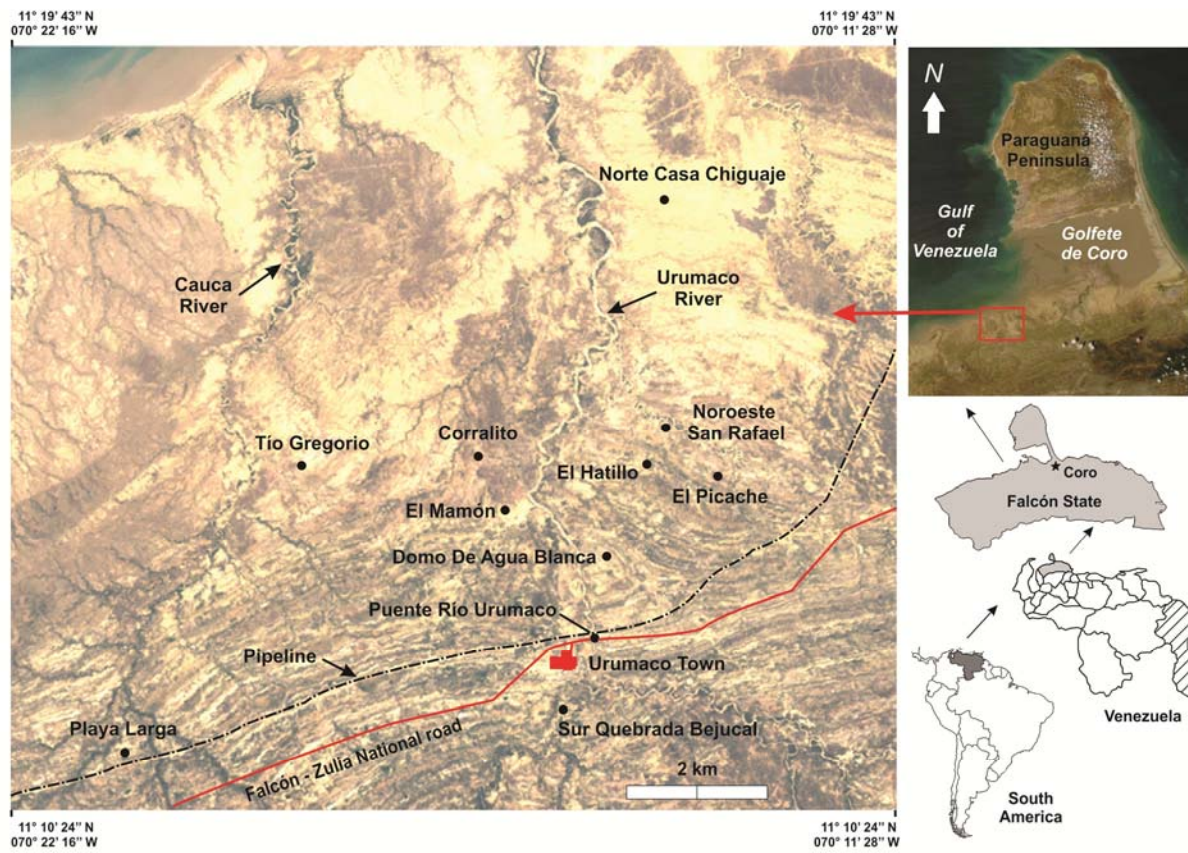
**Supplementary Information for:**

**Crocodylian diversity peak and extinction in the late Cenozoic of the northern  
Neotropics**

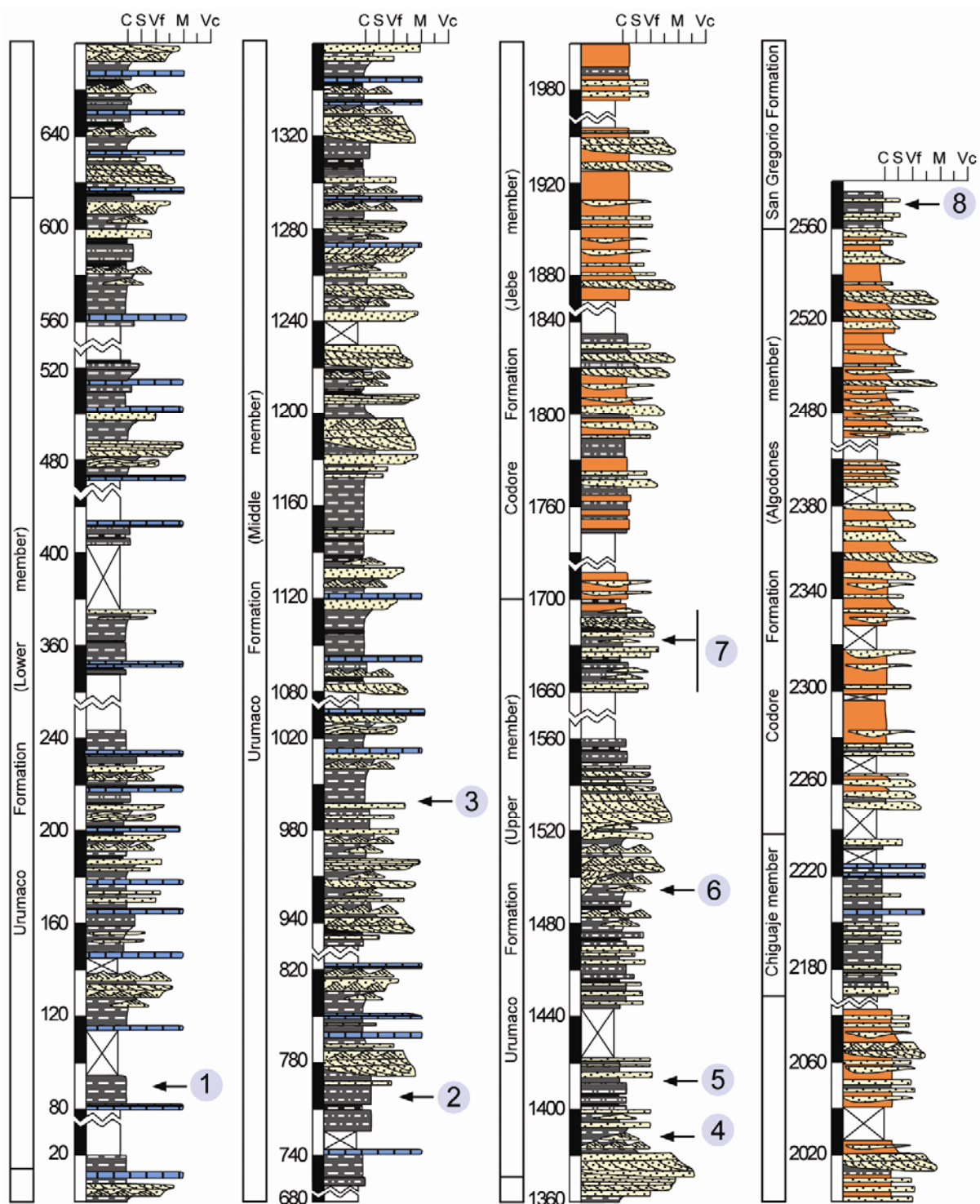
Scheyer, T. M., Aguilera, O. A., Delfino, M., Fortier, D. C., Carlini, A. A., Sánchez, R.,  
Carrillo-Briceño, J. D., Quiroz, L. & Sánchez-Villagra, M. R.

## Supplementary Figures

Supplementary Figure S1. Satellite image of Urumaco region with localities.















**Supplementary Figure S2. Detailed stratigraphic log showing the localities in the Urumaco and San Gregorio Formations used herein.**



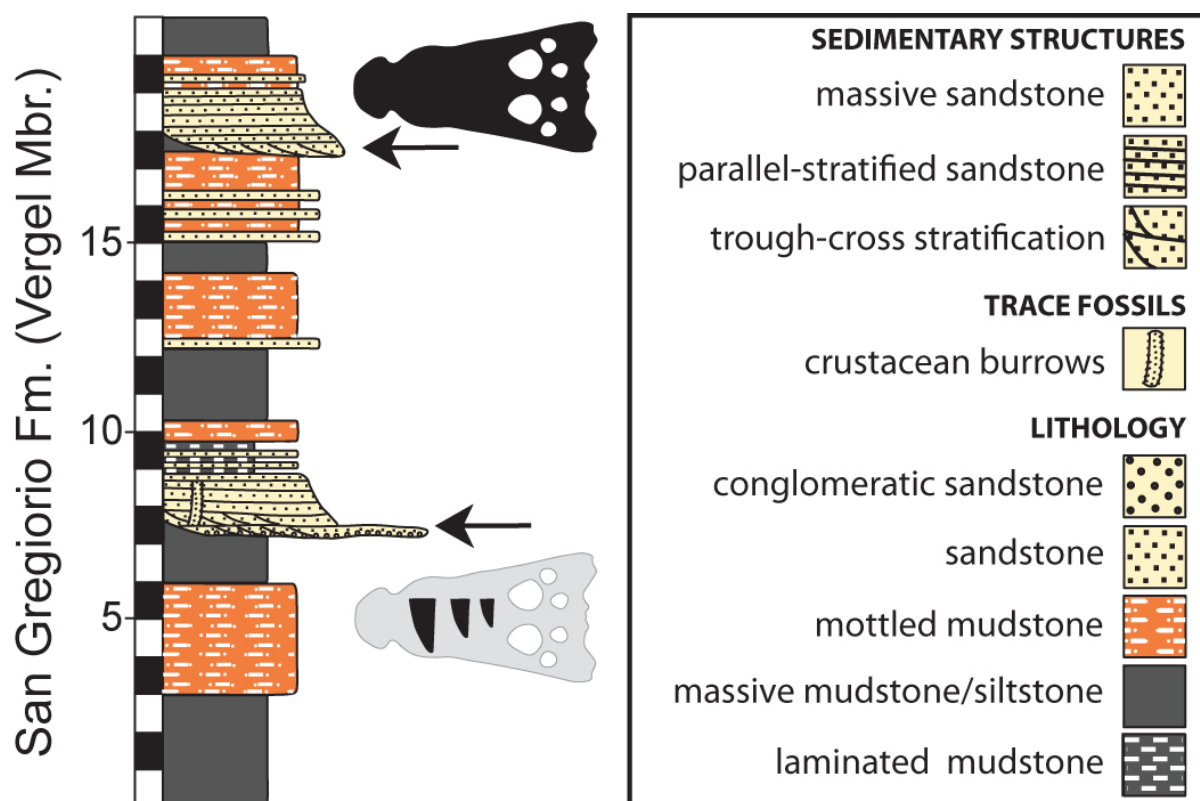
Modified from Quiroz and Jaramillo<sup>54</sup>. Locality names and coordinates are compiled in Supplementary Table 1. For legend see Supplementary Figure 2.

**Supplementary Figure S3. Legend accompanying stratigraphic log in Figure S2.**

LITHOLOGY		SEDIMENTARY STRUCTURES	
sandstone		massive	
mottled mudstone		parallel-stratified	
laminated mudstone/shale; organic-rich mudstone		trough-cross stratification	
massive mudstone/siltstone; with coal seam		ripple-cross bedding	
coquinoid limestone		hummocky-cross bedding	
cover interval			
non-exposure			

Modified from Quiroz and Jaramillo<sup>54</sup>.

**Supplementary Figure S4. Detailed stratigraphic log of the Vergel Member of the San Gregorio Formation and its accompanying legend.**



Note that the horizons where the holotype (black skull outline, adapted from Brochu<sup>55</sup>) and referred material (teeth in grey skull outline) were found in, are marked by black arrows.



**Supplementary Figure S5. Series of isolated teeth from the early Pliocene Vergel Member of the San Gregorio Formation.**



The specimens (AMU-CURS-302) were collected 1 km from the holotype (11° 17' 56.4" N, 70° 13' 52.8" W) of *Crocodylus falconensis* sp. nov. Scale bar = 1.0 cm.

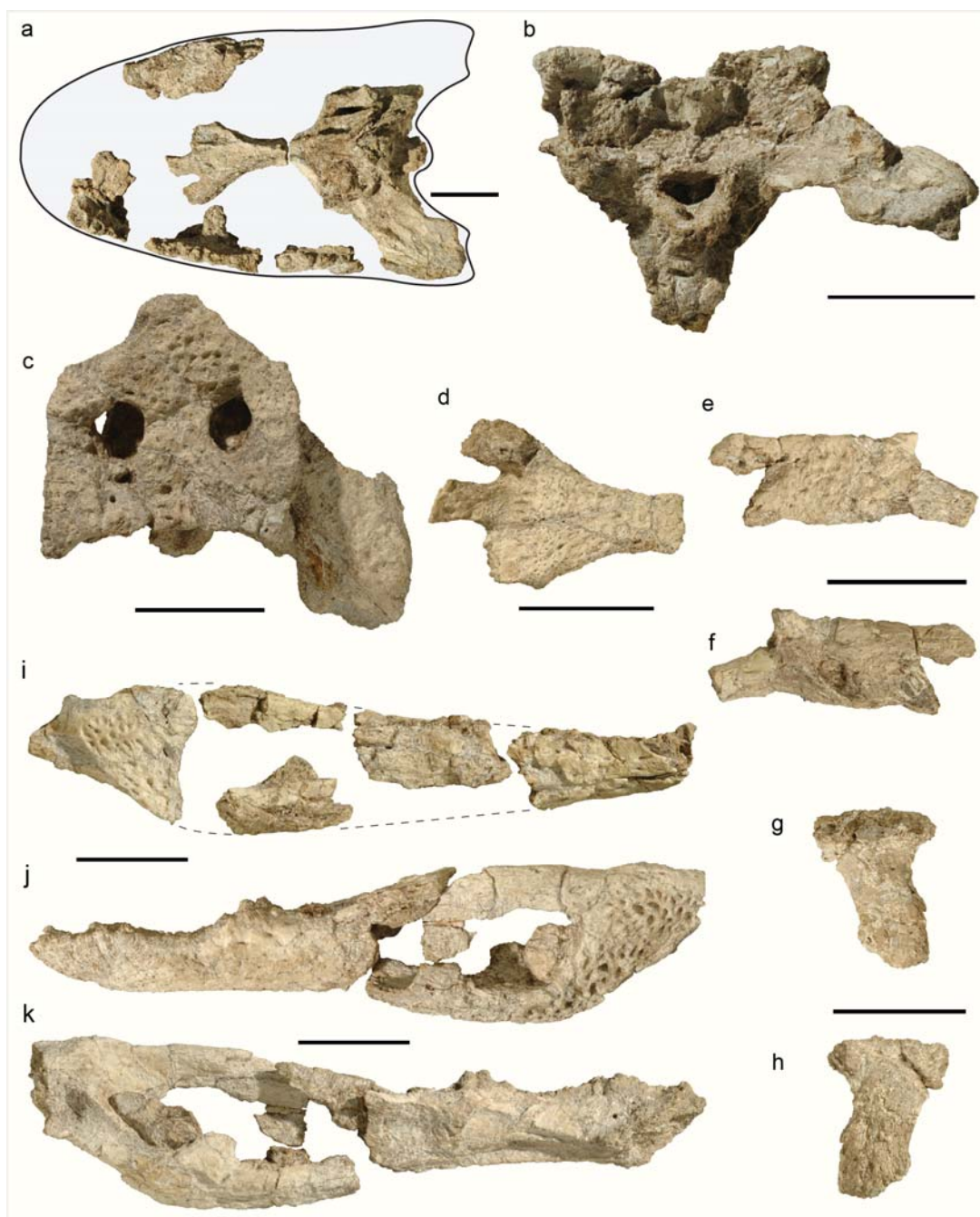
**Supplementary Figure S6. Holotype skull AMU-CURS-300 of *Crocodylus falconensis* sp. nov.**



**(a)** Rostral view of skull. **(b)** Left lateral view of rostrum. **(c)** Occipital view of skull. Note that even though the skull is damaged, the ventral extension of the supraoccipital (so) is visible, reaching or almost reaching the foramen magnum (fm). Scale bars = 5.0 cm.

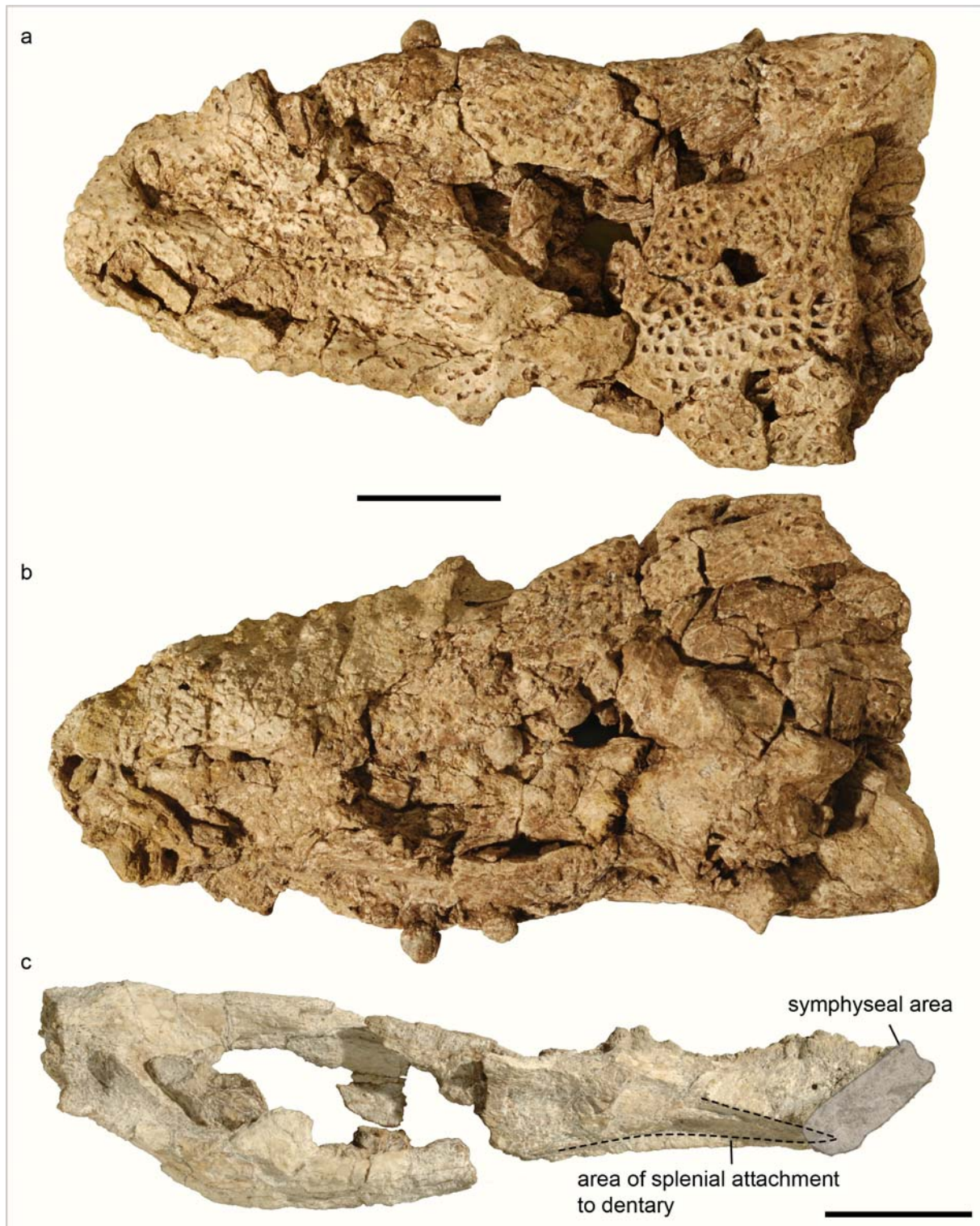


**Supplementary Figure S7. Paratype material AMU-CURS-224 of *Globidentosuchus brachyrostris* gen. et sp. nov.**



(a) Skull table/braincase, frontals and tooth-bearing elements and their assumed position in palatal view. (b) Skull table and braincase in occipital view. (c) Skull table and braincase in dorsal view. (d) Frontals in dorsal view. (e) Left jugal in lateral view. (f) Left jugal in medial view. (g) Left ectopterygoid in lateral view. (h) Left ectopterygoid in medial view. (i) Assembled right mandible in lateral view. (j) Assembled left mandible in lateral view. (k) Assembled left mandible in medial view. Scale bars = 5.0 cm.

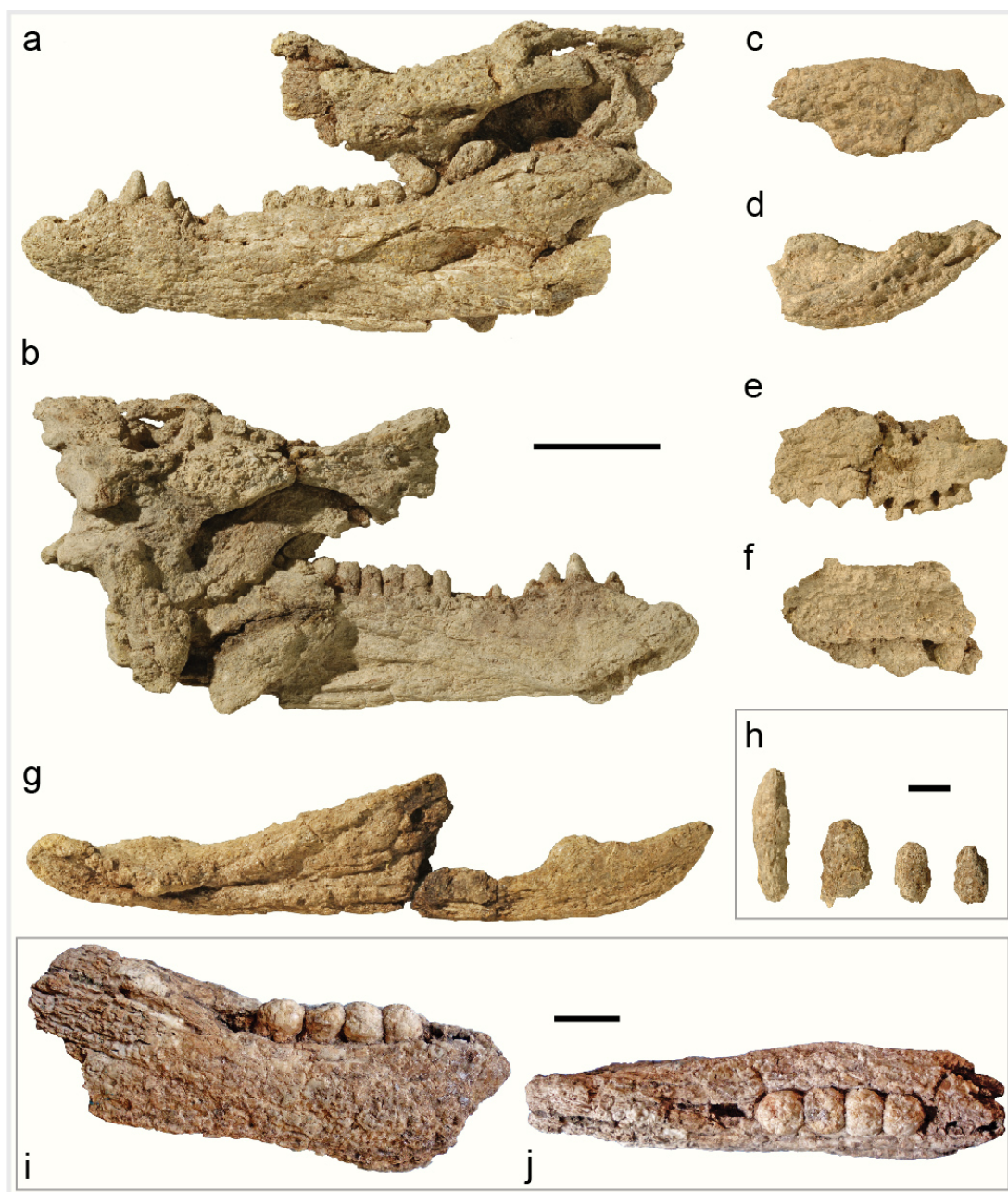
**Supplementary Figure S8. Selected holotype and paratype material of *Globidentosuchus brachyrostris* gen. et sp. nov.**



**(a)** Holotype skull (AMU-CURS-222, not mirror-imaged) in dorsal view. **(b)** Holotype skull in ventral view. **(c)** Left mandible of paratype (AMU-CURS-224) in which the extension of the splenial scar and the symphyseal area is indicated (compare to Supplementary Figure S7k). Scale bars = 5.0 cm.

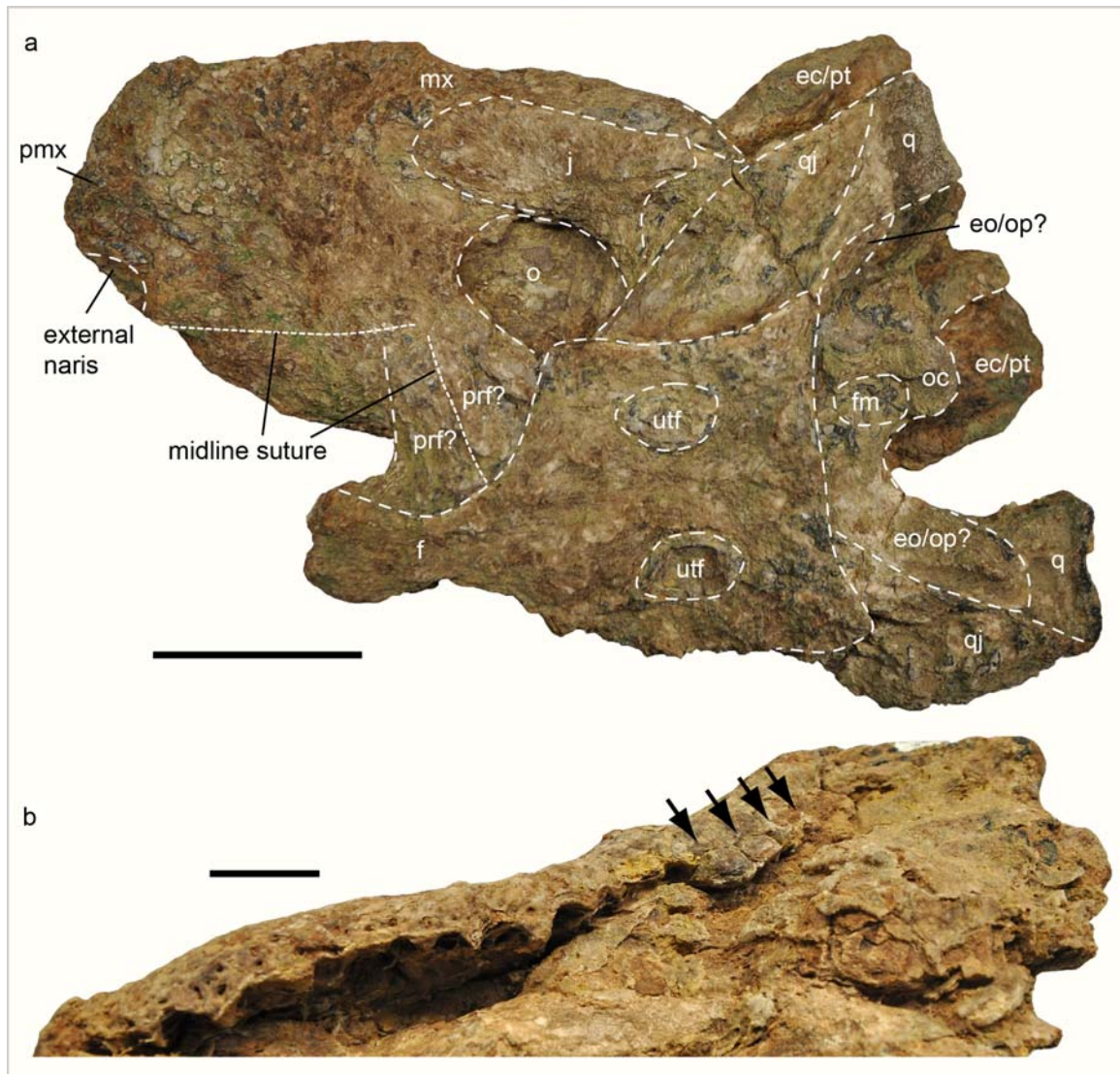


**Supplementary Figure S9. Referred material of *Globidentosuchus brachyrostris* gen. et sp. nov.**



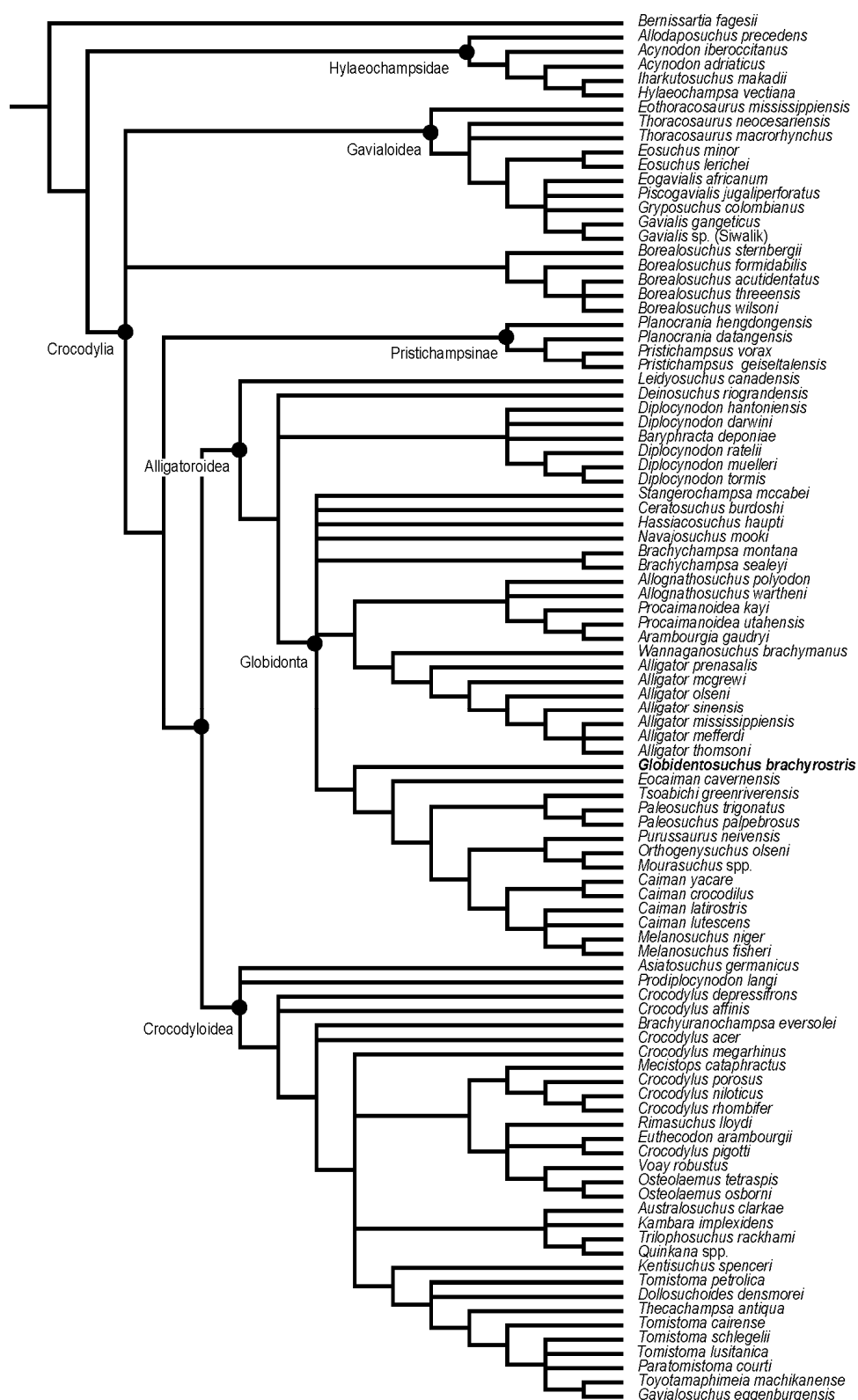
**(a-h)** Associated fragmentary cranial and mandibular remains (AMU-CURS-223). **(i, j)** Posterior part of right mandible showing four bulbous crushing teeth (AMU-CURS-301) in **(i)** lateral and **(j)** dorsal view. Part of skull roof and anterior part of left mandible in **(a)** lateral view and **(b)** medial view. **(c)** Left surangular in lateral view. **(d)** Left angular in lateral view. **(e)** Maxillary fragment showing alveoli in palatal view. **(f)** Maxillary fragment with bulbous tooth in lateral view. **(g)** Assembled right mandible fragment in medial view. **(h)** Series of teeth associated with the cranial remains. Scale bars = 5.0 cm in **(a-f)**, 1.0 cm in **(h)** and 2.0 cm in **(i, j)**.

**Supplementary Figure S10. Referred material of *Globidentosuchus brachyrostris* gen. et sp. nov.**



(a) Distorted skull (AMU-CURS-383) in dorsal view. Note that size of specimen is comparable to paratype specimen AMU-CURS 224 (based on skull table proportions). The rostrum is dislocated from the skull table and most of the tip of the snout and left side of rostrum has been folded and displaced ventrally. Due to strong weathering of the skull, most sutures are not traceable. (b) Left side of skull in oblique ventral view. The lateral walls of 13 alveoli of the anterior part of the left maxilla (maybe including also posterior end of premaxilla?) are visible. In the posterior part of the maxilla four closely spaced crushing teeth are still partly preserved (black arrows). Abbreviations: eo/op: exoccipital/opisthotic; f, frontal; fm, foramen magnum; j, jugal; mx, maxilla; o, orbit; oc, occipital condyle; pmx, premaxilla; prf, prefrontal; ec/pt, ectopterygoid and pterygoid; q, quadrate; qj, quadratojugal. Scale bars = 5.0 cm in (a) and 2.0 cm in (b).

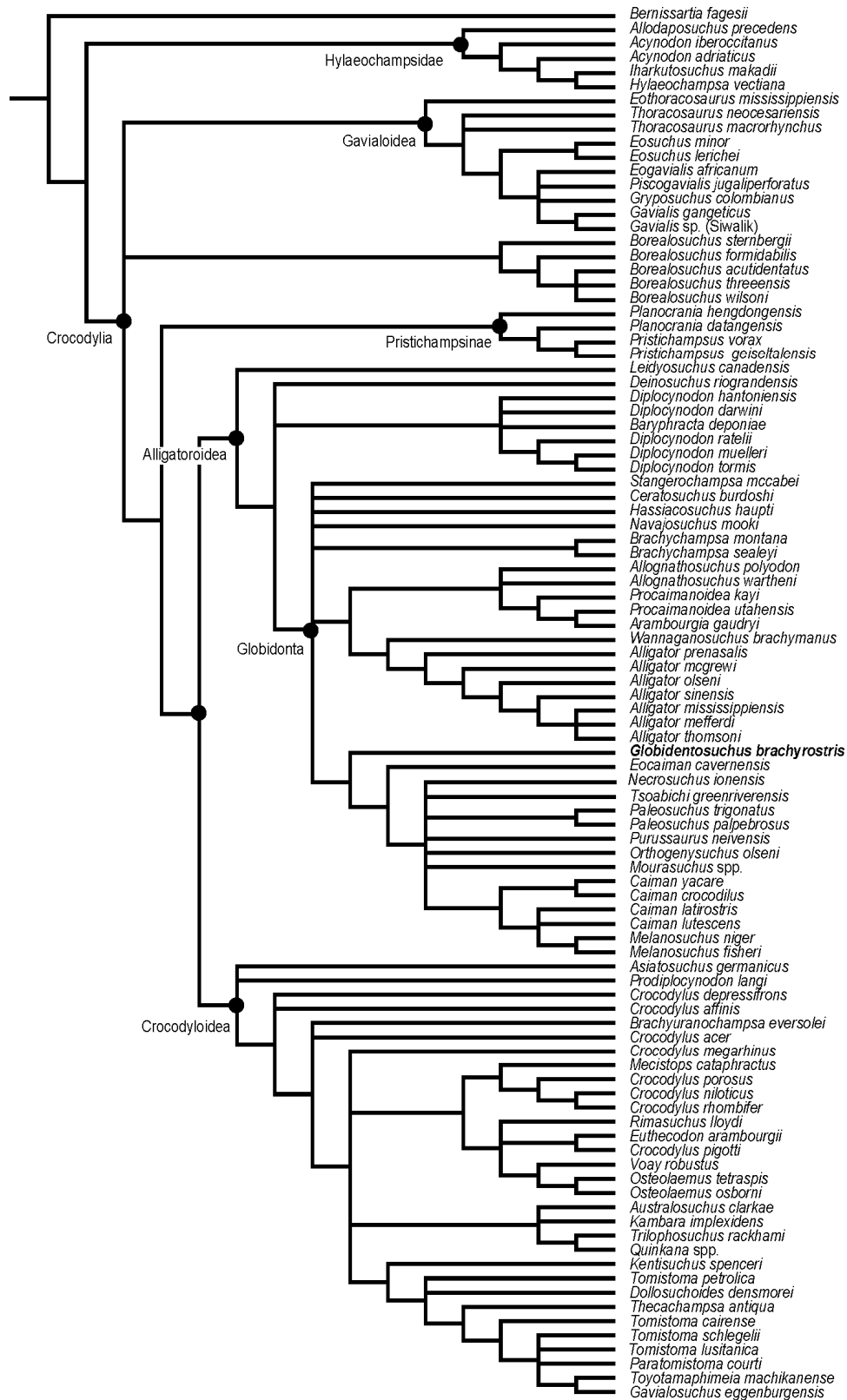
**Supplementary Figure S11. Phylogenetic analysis including the new caimanine taxon.**



Strict consensus tree of 20160 most parsimonious trees (tree length=650 steps) recovered by TNT analysis. The new taxon is marked in bold.



**Supplementary Figure S12. Phylogenetic analysis including the new caimanine taxon and *Necrosuchus ionensis*.**



Strict consensus tree of 24100 most parsimonious trees (tree length=650 steps) recovered by TNT analysis. The new taxon is marked in bold. Note loss of resolution within Caimaninae.

**Supplementary Table S1. Locality coordinates.**

## Socorro Formation localities

Quebrada Honda (Llano Largo)	11° 11' 35.00" N; 70° 10' 49.00" W
Quebrada Honda (Cerro Maniaero)	11° 11' 00.90" N, 70° 09' 44.00" W
Quebrada Honda (Cerro Alto)	11° 12' 30.00" N; 70° 08' 12.00" W

## Urumaco Formation localities

Sur Quebrada Bejucal (1)	11° 11' 18.46" N; 70° 15' 03.00" W
Puente Río Urumaco (2)	11° 12' 24.66" N; 70° 14' 59.27" W
Playa Larga (2)	11° 10' 58.00" N, 70° 20' 50.00" W
Domo de Agua Blanca (3)	11° 13' 25.00" N; 70° 14' 50.00" W
El Hatillo (4)	11° 14' 34.00" N; 70° 14' 20.00" W
El Mamón (5)	11° 13' 60.00" N; 70° 16' 06.00" W
El Picache (6)	11° 14' 25.00" N; 70° 13' 27.00" W
Noroeste (NW) San Rafael (6)	11° 14' 52.00" N; 70° 14' 06.00" W
Corralito (7)	11° 14' 40.00" N; 70° 16' 26.00" W
Tío Gregorio (7)	11° 14' 33.13" N; 70° 18' 38.00" W

## San Gregorio Formation localities

Norte Casa Chiguaje (8)	11° 17' 52.00" N; 70° 14' 07.80" W
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Numbers in brackets behind location names correspond to the number system used for the study (see locality numbers in Supplementary Figure 2). In the case of Puente Río Urumaco/Playa Larga, El Picache/ Noroeste (NW) San Rafael and Tío Gregorio/Corralito, the localities have been combined under numbers (2), (6) and (7) respectively, because of their close proximity in the stratigraphic column. Coordinates of Urumaco town for reference: 11° 17' 53.9" N, 70° 14' 33.7" W.

**Supplementary Table S2. List of fossil material examined.**

Formation/Locality	Specimen Number	Taxon	Material present
<b>Socorro Formation (pooled localities)</b>			
	AMU-CURS-031	<i>Purussaurus</i> sp.	Right mandible
	AMU-CURS-034	?cf. <i>Thecachampsa</i> sp. 1	Cranium and rostrum
	AMU-CURS-095	<i>Mourasuchus</i> sp.	Partial rostrum
	AMU-CURS-141	<i>Mourasuchus</i> sp.	Mandible
	AMU-CURS-151	<i>Caiman</i> sp.	Cranium
	AMU-CURS-433	<i>Ikanogavialis gameroi</i>	Rostrum
<b>Urumaco Formation</b>			
Sur Quebrada Bejucal (1)			
	AMU-CURS-018	<i>Caiman</i> sp.	Mandible
	AMU-CURS-020	<i>Purussaurus</i> sp.	Cranial and postcranial remains
	AMU-CURS-unnumbered	<i>Mourasuchus</i> sp.	Partial cranial remains
Puente Río Urumaco/ Playa Larga (2)			
	AMU-CURS-001	<i>Hesperogavialis cruxenti</i>	Cranium and rostrum
	AMU-CURS-113	<i>Caiman</i> sp.	Cranium
	AMU-CURS-217	<i>Melanosuchus fisheri</i>	Cranium
	AMU-CURS-218	<i>Mourasuchus nativus</i>	Cranium
	MCN-URU-2002-unnumbered	<i>Ikanogavialis gameroi</i>	Cranium and rostrum
Domo de Agua Blanca (3)			
	AMU-CURS-012	?cf. <i>Thecachampsa</i> sp. 2	Cranium and mandible
	AMU-CURS-132	<i>Hesperogavialis cruxenti</i>	Rostrum
	AMU-CURS-301	<i>Globidentosuchus brachyrostris</i> (referred material)	Posterior part of right mandible with four crushing teeth
	AMU-CURS-450	<i>Globidentosuchus brachyrostris</i> (referred material)	partial mandibular remains
El Hatillo (4)			
	AMU-CURS-134	<i>Gryposuchus croizati</i>	Rostrum
	AMU-CURS-135	<i>Purussaurus mirandai</i> (paratype)	Cranium with associated mandibles
	AMU-CURS-234	<i>Melanosuchus fisheri</i>	Cranium and mandibles (also postcranium)
	AMU-CURS-unnumbered	<i>Charactosuchus mendesi</i>	partial cranial remains

El Mamón (5)	AMU-CURS-unnumbered	<i>Mourasuchus arendsi</i>	partial cranial remains
	AMU-CURS-212	<i>Mourasuchus nativus</i>	Cranial fragment
	AMU-CURS-429	<i>Caiman brevirostris</i>	Cranial/mandibular fragments
	UNEFM-CIAPP-319	<i>Hesperogavialis cruxenti</i>	Rostrum
El Picache (6)	UNEFM-CIAPP-320	<i>Hesperogavialis cruxenti</i> (holotype)	Partial cranium and rostrum
	AMU-CURS-222	<i>Globidentosuchus brachyrostris</i> (holotype)	Cranium and mandibles
	AMU-CURS-223	<i>Globidentosuchus brachyrostris</i> (referred material)	Associated fragmentary cranial and mandibular remains
	AMU-CURS-224	<i>Globidentosuchus brachyrostris</i> (paratype)	Fragmentary cranial remains associated with mandibles
NW San Rafael (6)	AMU-CURS-unnumbered	<i>Purussaurus</i> sp.	Cranium and mandibular remains
	MCN- unnumbered	<i>Caiman brevirostris</i>	Cranium with associated mandibles
	AMU-CURS-383	<i>Globidentosuchus brachyrostris</i> (referred material)	Cranium and mandibles
	AMU-CURS-384	<i>Purussaurus</i> sp.	Left mandible
Corralito (7)	AMU-CURS-390	<i>Mourasuchus</i> sp.	Mandibular fragment
	AMU-CURS-395	<i>Mourasuchus</i> sp.	Cranial fragments
	AMU-CURS-396	<i>Mourasuchus</i> sp.	Cranial fragments
	AMU-CURS-399	<i>Gryposuchus</i> sp.	Cranial fragments
Tío Gregorio (7)	AMU-CURS-049	<i>Caiman lutescens</i>	Partial rostrum
	AMU-CURS-090	<i>Caiman</i> sp.	Cranium and rostrum
	AMU-CURS-unnumbered	<i>Purussaurus</i> sp.	Cranial remains
	MCN-243	<i>Melanosuchus fisheri</i> (holotype)	Cranium and rostrum
	UNEFM-CIAPP-617	<i>Gryposuchus jessei</i>	Rostrum
	UNEFM-CIAPP-1297	<i>Mourasuchus arendsi</i> (holotype)	Skull and mandible
	UNEFM-CIAAP-1440	<i>Gryposuchus croizati</i> (paratype)	Mandible
	AMU-CURS-057	<i>Purussaurus</i> sp.	Mandible
	AMU-CURS-058	<i>Gryposuchus croizati</i> (paratype)	Cranium and rostrum and postcranial material
	AMU-CURS-073	<i>Mourasuchus</i> sp.	Right mandible and incomplete rostrum and

	AMU-CURS-105	<i>Caiman brevirostris</i>	postcranial material
	AMU-CURS-106	<i>Caiman brevirostris</i>	Cranium
	AMU-CURS-unnumbered	<i>Purussaurus</i> sp.	Mandible
	MCN-URU-2002-143	<i>Ikanogavialis gameroi</i>	partial cranial remains
	UCV-VF-1165	<i>Ikanogavialis gameroi</i> (holotype)	Cranium and rostrum
	UCV-VF-1166	<i>Ikanogavialis gameroi</i> (holotype)	Cranium
			Mandible
<b>San Gregorio Formation locality</b>			
<hr/>			
	Norte Casa Chiguaje (8)		
	AMU-CURS-300	<i>Crocodylus falconensis</i> (holotype)	Almost complete skull with mandibles
	AMU-CURS-302	<i>Crocodylia</i> indet.	Series of isolated teeth

Abbreviations: UNEFM-CIAAP, Universidad Nacional Experimental Francisco de Miranda, Coro, Venezuela; MCN, Museo de Ciencias Naturales de Caracas, Venezuela; AMU-CURS, Colección de Paleontología de Vertebrados de la Alcaldía de Urumaco, Estado Falcón, Venezuela; UCV, Universidad Central de Venezuela, Maracay, Venezuela.



**Supplementary Table S3. Length estimations I.**

New <i>Crocodylus</i> species	DCL = 59.0 [cm], SL = 42.5 [cm], ODCL = 165.0 [mm]	
<i>Gavialis gangeticus</i> formula	(modif. from Sereno et al. <sup>56</sup> )	
TL = (7.4 * DCL) – 69.369	TL = (7.4 * 59.0) – 69.369	TL = 367.23
<i>Crocodylus porosus</i> formula	(modif. from Sereno et al. <sup>56</sup> )	
TL = (7.717 * DCL) – 20.224	TL = (7.717 * 59.0) – 20.224	TL = 435.08
<i>Crocodylus moreletii</i> formula	(modif. from Platt et al. <sup>57</sup> )	
TL = (10.48 * SL) + 6.20	TL = (10.48 * 42.5) + 6.20	TL = 451.60
<i>Crocodylus acutus</i> formula	(modif. from Platt et al. <sup>58</sup> )	
TL = (9.01 * SL) + 10.80	TL = (9.01 * 42.5) + 10.80	TL = 393.73
<i>Alligator mississippiensis</i> formula	(modif. from Hurlburt et al. <sup>59</sup> )	
Log TL = (log ODCL * 1.259) + 0.793	Log TL = (log 165.0 * 1.259) + 0.793	TL = 384.43
Log TL = (log DCL * 0.970) + 0.954	Log TL = (log 590.0 * 0.970) + 0.954	TL = 438.25
Mean = 411.72		
New caimanine species	DCL = 29.0 [cm], SL = 14.0 [cm] ODCL = 150.0 [mm]	
<i>Gavialis gangeticus</i> formula	(modif. from Sereno et al. <sup>56</sup> )	
TL = (7.4 * DCL) – 69.369	TL = (7.4 * 29.0) – 69.369	TL = 145.23
<i>Crocodylus porosus</i> formula	(modif. from Sereno et al. <sup>56</sup> )	
TL = (7.717 * DCL) – 20.224	TL = (7.717 * 29.0) – 20.224	TL = 203.57
<i>Crocodylus moreletii</i> formula	(modif. from Platt et al. <sup>57</sup> )	
TL = (10.48 * SL) + 6.20	TL = (10.48 * 14.0) + 6.20	TL = 152.92
<i>Crocodylus acutus</i> formula	(modif. from Platt et al. <sup>58</sup> )	
TL = (9.01 * SL) + 10.80	TL = (9.01 * 14.0) + 10.80	TL = 136.94
<i>Alligator mississippiensis</i> formula	(modif. from Hurlburt et al. <sup>59</sup> )	
Log TL = (log ODCL * 1.259) + 0.793	Log TL = (log 150.0 * 1.259) + 0.793	[TL = 340.96*]
Log TL = (log DCL * 0.970) + 0.954	Log TL = (log 290.0 * 0.970) + 0.954	TL = 220.05
Mean = 171.74 [199.95*]		

Total body length (TL) estimations in [cm] using dorsal cranial length (DCL), snout length (SL) and orbito-cranial length (ODCL). Note that for the *Alligator*-based formula<sup>59</sup>, values have to be entered in millimeters. Results are rounded to the nearest [mm].

**Supplementary Table S4. Length estimations II.**

New <i>Crocodylus</i> species	DCL = 59.0, SL = 42.5	
<i>Crocodylus porosus</i> formula	(modif. from Webb and Messel <sup>60</sup> )	
SVL = (3.60 * DCL) - 4.30	SVL = (3.60 * 59.0) - 4.30	SVL = 208.10
<i>Crocodylus moreletii</i> formula	(modif. from Platt et al. <sup>57</sup> )	
SVL = (5.32 * SL) + 1.61	SVL = (5.32 * 42.5) + 1.61	SVL = 227.71
<i>Crocodylus acutus</i> formula	(modif. from Platt et al. <sup>58</sup> )	
SVL = (4.68 * SL) + 4.57	SVL = (4.68 * 42.5) + 4.57	SVL = 203.47
		Mean = 213.09
New caimanine species	DCL = 29.0, SL = 14.0	
<i>Crocodylus porosus</i> formula	(modif. from Webb and Messel <sup>60</sup> )	
SVL = (3.60 * DCL) - 4.30	SVL = (3.60 * 29.0) - 4.30	SVL = 100.10
<i>Crocodylus moreletii</i> formula	(modif. from Platt et al. <sup>57</sup> )	
SVL = (5.32 * SL) + 1.61	SVL = (5.32 * 14.0) + 1.61	SVL = 76.09
<i>Crocodylus acutus</i> formula	(modif. from Platt et al. <sup>58</sup> )	
SVL = (4.68 * SL) + 4.57	SVL = (4.68 * 14.0) + 4.57	SVL = 70.09
		Mean = 82.09

Snout-vent length (SVL) estimations in [cm] using dorsal cranial length (CL) and snout length (SL); results are rounded to the nearest [mm].

### Supplementary Table S5. Mass estimations.

New <i>Crocodylus</i> species	mean SVL = 213.09, mean TL= 411.72	
<i>Crocodylus porosus</i> formula	(modif. from Webb and Messel <sup>60</sup> )	
$\log \text{BM} = (3.2613 * \log \text{SVL}) - 2.0894$	$\log \text{BM} = (3.2613 * \log 213.09) - 2.0894$	BM = 319.70
<i>Crocodylus moreletii</i> formula	(modif. from Platt et al. <sup>57</sup> )	
$\ln \text{BM} = (\ln \text{TL} - 2.05) / 0.32$	$\ln \text{BM} = (\ln 411.72 - 2.05) / 0.32$	BM = 244.58
$\ln \text{BM} = (\ln \text{SVL} - 1.25) / 0.33$	$\ln \text{BM} = (\ln 213.09 - 1.25) / 0.33$	BM = 257.75
<i>Crocodylus acutus</i> formula	(modif. from Platt et al. <sup>58</sup> )	
$\ln \text{BM} = (\ln \text{TL} - 2.06) / 0.31$	$\ln \text{BM} = (\ln 411.72 - 2.06) / 0.31$	BM = 353.38
$\ln \text{BM} = (\ln \text{SVL} - 1.27) / 0.32$	$\ln \text{BM} = (\ln 213.09 - 1.27) / 0.32$	BM = 357.40
		Mean = 306.56
New caimanine species	mean SVL = 82.09, mean TL = 171.74 [mean TL = 199.95*]	
<i>Crocodylus porosus</i> formula	(modif. from Webb and Messel <sup>60</sup> )	
$\log \text{BM} = (3.2613 * \log \text{SVL}) - 2.0894$	$\log \text{BM} = (3.2613 * \log 82.09) - 2.0894$	BM = 14.25
<i>Crocodylus moreletii</i> formula	(modif. from Platt et al. <sup>57</sup> )	
$\ln \text{BM} = (\ln \text{TL} - 2.05) / 0.32$	$\ln \text{BM} = (\ln 171.74 - 2.05) / 0.32$	BM = 15.91 [25.59*]
$\ln \text{BM} = (\ln \text{SVL} - 1.25) / 0.33$	$\ln \text{BM} = (\ln 82.09 - 1.25) / 0.33$	BM = 14.32
<i>Crocodylus acutus</i> formula	(modif. from Platt et al. <sup>58</sup> )	
$\ln \text{BM} = (\ln \text{TL} - 2.06) / 0.31$	$\ln \text{BM} = (\ln 171.74 - 2.06) / 0.31$	BM = 21.05 [34.39*]
$\ln \text{BM} = (\ln \text{SVL} - 1.27) / 0.32$	$\ln \text{BM} = (\ln 82.09 - 1.27) / 0.32$	BM = 18.14
		Mean = 16.73 [21.34*]

Body Mass (BM) estimations in [kg] using total length (TL) and snout-vent length (SVL) in [cm]; results are rounded to the nearest [mm].

## **Supplementary Notes**

### **Supplementary Note 1: Stratigraphic and Palaeoenvironmental Context of New Taxa**

#### **New *Crocodylus* species**

The new *Crocodylus* species comes from outcrops that have only recently been discovered to be fossiliferous and described, so we provide here a context for future reference in explorations, or in stratigraphical, taphonomical or palaeoecological studies. The San Gregorio Formation is the upper-most part of the large Urumaco sequence<sup>54</sup>. The contact between the Codore and San Gregorio Formations is transitional near the Urumaco River area, and the age is early Pliocene. It is exposed in the north-central area of the Falcon State coastal plain, 10 km north of the Urumaco Town. The fossiliferous outcrops are of the lower part of the Vergel Member of the San Gregorio Formation (Supplementary Figure 4), consisting of brown to dark gray, massive mudstone and mottled muddy sandstone, interbedded with massive to cross-bedded conglomeratic sandstone with lenticular geometry and erosive base, grading to parallel-stratified, fine to medium grained sandstone. This succession represents flood plain deposits and associated crevasse splays, with low sinuosity ephemeral channels mostly filled during river flooding, in an alluvial fan setting. The lateral outflow of the channels during inundate events form a sub-aerial savannas, such as, wetlands. The results of these inundate soils are palaeosols over sandy deposits, characterized by the presence of a terrestrial and semi-aquatic fossil assemblage, including mammals<sup>61</sup>. The faunal assemblage represents the last testimonies of the hydrographic and climate change around the Miocene/Pliocene boundary.

#### **New caimanine species**

The type and most of the referred material of the new caimanine come from the El Picache locality, Upper Member of the Urumaco Formation, whereas the isolated mandible (AMU-CURS-223) was recovered from the Middle Member of the Urumaco Formation. The sedimentary environments of the Urumaco Formation have been described in Quiroz and Jaramillo<sup>54</sup> (see stratigraphic logs in Fig. 1 and Supplementary Figures 2-4). According to the authors, both the Middle and Upper Member are composed of siliciclastic sequences and intercalated limestone beds deposited in a prograding delta and strand plain environment.

## **Supplementary Note 2: Major Expeditions to the Fossiliferous Outcrops around Urumaco**

Expeditions to the Urumaco region were conducted by Royo y Gómez from Universidad Central de Venezuela in Caracas (1958-1959), C. González de Juana at Universidad Central de Venezuela together with Bryan Patterson from Harvard University (1972), Jean Bocquentin-Villanueva (1982 and following years in the 1980s) and by Orangel Aguilera (1992-2012) at the Universidad Francisco de Miranda in Coro, R. Sánchez at Alcaldía de Urumaco and Smithsonian Tropical Research Institute (1990-2012), M. Sánchez-Villagra from University of Tübingen (2002-2004), The Natural History Museum in London (2004-2006), and from University of Zürich (2007-2012).



### Supplementary Note 3: Phylogenetic Analyses

#### New *Crocodylus* species

The dataset for the testing the position of the new *Crocodylus* species comprised 32 characters in total (coding 29 characters that vary inside Crocodylinae<sup>62</sup> plus two new characters), 14 ingroup taxa and the outgroup consisting of the basal crocodiline “*Crocodylus*” *megarhinus* and the three osteolaemines “*Crocodylus*” *pigotti*, *Rimasuchus lloydi* and *Voay robustus*.

#### Character description

1. Ventral tubercle of proatlas more than one-half (0) or no more than one half (1) the width of the dorsal crest. (Brochu et al.<sup>62</sup>, character 1)
2. Fused proatlas boomerang-shaped (0), strap-shaped (1), or massive and block-shaped (2). (Brochu et al.<sup>62</sup>, character 2)
3. Anterior half of axis neural spine oriented horizontally (0) or slopes anteriorly (1). (Brochu et al.<sup>62</sup>, character 6)
4. Axis neural spine crested (0) or not crested (1). (Brochu et al.<sup>62</sup>, character 7)
5. Posterior half of axis neural spine wide (0) or narrow (1). (Brochu et al.<sup>62</sup>, character 8)
6. Hypapophyseal keels present on eleventh vertebra behind atlas (0), twelfth vertebra behind atlas (1), or tenth vertebra behind atlas (2). (Brochu et al.<sup>62</sup>, character 9)
7. Third cervical vertebra (first postaxial) with prominent hypapophysis (0) or lacks prominent hypapophysis (1). (Brochu et al.<sup>62</sup>, character 10)
8. Neural spine on third cervical long, dorsal tip at least half the length of the centrum without the cotyle (0) or short, dorsal tip acute and less than half the length of the centrum without the cotyle (1). (Brochu et al.<sup>62</sup>, character 11)
9. Scapulocoracoid facet anterior to glenoid fossa uniformly narrow (0) or broad immediately anterior to glenoid fossa, and tapering anteriorly (1). (Brochu et al.<sup>62</sup>, character 14)
10. Proximal edge of deltopectoral crest emerges smoothly from proximal end of humerus and is not obviously concave (0) or emerges abruptly from proximal end of humerus and is obviously concave (1). (Brochu et al.<sup>62</sup>, character 15)
11. Dorsal margin of iliac blade rounded with smooth border (0) or rounded, with modest dorsal indentation (1) or rounded, with strong dorsal indentation (“wasp-waisted;” 2) or narrow, with dorsal indentation (3) or rounded with smooth border; posterior tip of blade very deep (4). (Brochu et al.<sup>62</sup>, character 19)
12. Supraacetabular crest narrow (0) or broad (1). (Brochu et al.<sup>62</sup>, character 20)

13. Dentary symphysis extends to fourth or fifth alveolus (0) or sixth through eighth alveolus (1) or behind eighth alveolus (2.) (Brochu et al.<sup>62</sup>, character 28)
14. Angular-surangular suture contacts external mandibular fenestra at posterior angle at maturity (0) or passes broadly along ventral margin of external mandibular fenestra late in ontogeny (1). (Brochu et al.<sup>62</sup>, character 34)
15. Dorsal surface of rostrum curves smoothly (0) or bears medial dorsal boss (1). (Brochu et al.<sup>62</sup>, character 52)
16. Preorbital ridges absent or very modest (0) or very prominent (1) at maturity. (Brochu et al.<sup>62</sup>, character 53)
17. Surface of maxilla within narial canal imperforate (0) or with a linear array of pits (1.) (Brochu et al.<sup>62</sup>, character 55)
18. Anterior ectopterygoid process tapers to a point (0) or forked (1). (Brochu et al.<sup>62</sup>, character 63)
19. Palatine process generally broad anteriorly (0) or in form of thin wedge (1). (Brochu et al.<sup>62</sup>, character 65)
20. Palatine-pterygoid suture nearly at (0) or far from (1) posterior angle of suborbital fenestra. (Brochu et al.<sup>62</sup>, character 67)
21. Pterygoid surface lateral and anterior to internal choana flush with choanal margin (0) or pushed inward anterolateral to choanal aperture (1) or pushed inward around choana to form “neck” surrounding aperture (2) or everted from flat surface to form “neck” surrounding aperture (3). (Brochu et al.<sup>62</sup>, character 69)
22. Lacrimal makes broad contact with nasal; no posterior process of maxilla (0) or maxilla with posterior process within lacrimal (1) or maxilla with posterior process between lacrimal and prefrontal (2). (Brochu et al.<sup>62</sup>, character 71)
23. Quadratojugal extends to superior angle of infratemporal fenestra (0) or does not extend to superior angle of infratemporal fenestra; quadrate participates in fenestra (1). (Brochu et al.<sup>62</sup>, character 80; adapted from Buscalioni et al.<sup>63</sup> according to Brochu et al.<sup>64</sup>)
24. Posterolateral margin of squamosal horizontal or nearly so (0) or upturned to form a discrete “horn” (1.) (Brochu et al.<sup>62</sup>, character 86)
25. Squamosal does not extend (0) or extends (1) ventrolaterally to lateral extent of paraoccipital process. (Brochu et al.<sup>62</sup>, character 87)
26. Supraoccipital exposure on dorsal skull table small (0), absent (1), large (2), or large such that parietal is excluded from posterior edge of table (3). (Brochu et al.<sup>62</sup>, character 88)

27. Sulcus on anterior braincase wall lateral to basisphenoid rostrum (0) or braincase wall lateral to basisphenoid rostrum smooth; no sulcus (1). (Brochu et al.<sup>62</sup>, character 89)
28. Extensive exposure of prootic on external braincase wall (0) or prootic largely obscured by quadrate and laterosphenoid externally (1). (Brochu et al.<sup>62</sup>, character 91; adapted from Norell<sup>65</sup> according to Brochu et al.<sup>64</sup>)
29. Lateral eustachian canals open dorsal (0) or lateral (1) to medial eustachian canal. (Brochu et al.<sup>62</sup>, character 96; adapted from Norell<sup>66</sup> according to Brochu et al.<sup>64</sup>)
30. Posterior process of palatines with nearly parallel sides (0) or expands posteriorly (1). (This character was not used by Brochu et al.<sup>62</sup>, it is adapted, however, from character 2 of Norell<sup>66</sup> according to Brochu<sup>67</sup>)
31. Posterior margin of skull roof concave (0) or with a developed medial convexity (1) late in ontogeny. (NEW)
32. Anteriormost width of the intersuborbital bar wider than (0) or as wide as (1) the posteriormost width. (NEW)

### Character codings

Unknown or non-applicable characters were coded as question marks. Polymorphisms are noted in brackets.

<i>"Crocodylus" megarhinus</i>	????? ?0?? ?100 00001 02100 ?100? 00
<i>"Crocodylus" pigotti</i>	?00? ?0011 ?1?0 10111 1??01 0?100 11
<i>Rimasuchus lloydi</i>	????? ????? ????0 1?00? ?1101 0110? 00
<i>Voay robustus</i>	????? ????? 11100 10001 10111 1?100 01
<i>Mecistops cataphractus</i>	10000 00011 20110 00011 00100 01100 10
<i>Crocodylus palaeindicus</i>	????? ????? ?010 00100 00100 1011? 1?
<i>Crocodylus porosus</i>	11001 10101 20010 11(01)01 00100 01111 01
<i>Crocodylus palustris</i>	10001 01111 21010 11(01)01 00100 01111 01
<i>Crocodylus siamensis</i>	11111 00010 20010 11(01)01 00110 01111 00
<i>Crocodylus johnstoni</i>	11001 10101 20?10 11(01)11 00100 01110 00
<i>Crocodylus mindorensis</i>	11001 10101 20010 11(01)01 00100 01111 10
<i>Crocodylus novaeguineae</i>	11001 10101 20010 11(01)01 00000 01010 00
<i>Crocodylus niloticus</i>	10101 00111 20010 01(01)01 01100 01110 00
<b><i>Crocodylus falconensis</i> sp. nov.</b>	????? ????? ?011 01000 ?1?00 ????0 00
<i>Crocodylus acutus</i>	00101 00111 20011 01(01)00 21100 01111 11
<i>Crocodylus intermedius</i>	00101 00111 20111 01(01)00 20100 01111 11

<i>Crocodylus moreletii</i>	00101 00111 20011 01(01)00 21100 01111 10
<i>Crocodylus rhombifer</i>	00101 00111 10011 01(01)00 21110 01111 10

### Apomorphy List

The apomorphy list was constructed based on the tree shown in Figure 5a. ACCTRAN optimization in bold and DELTRAN optimization underlined.

Osteolaeminae: 12(1), 16(1), 22(1), 26(1)

*Rimasuchus lloydi*: 23(1)

“*Crocodylus*” *pigotti* + *Voay robustus*: 21(1), 32(1)

“*C*”. *pigotti*: 18(1), 19(1), 30(1)

*Voay robustus*: 12(1), 24(1), 26(1)

*Mecistops cataphractus* + *Crocodylus*: 11(2), 14(1), 30(1)

*Mecistops cataphractus*: 19(1), 30(1)

*C. palaeindicus* + Crown *Crocodylus*: 5(1), 8(1), 13(0), 29(1)

*C. palaeindicus*: 18(1), 20(0), 26(1), 26(0), 30(1)

Crown *Crocodylus*: 5(1), 8(1), 17(1), 30(0)

Indopacific *Crocodylus*: 16(1), 31(1)

*C. palustris*: 7(1), 12(1), 30(1), 32(1)

*C. siamensis* + *C. porosus* + *C. mindorensis* + *C. johnstoni* + *C. novaeguineae*: 2(1)

*C. siamensis*: 3(1), 4(1), 8(0), 10(0), 24(1)

*C. porosus* + *C. mindorensis* + *C. johnstoni* + *C. novaeguineae*: 6(1), 9(0)

*C. porosus*: 32(1)

*C. mindorensis*: 30(1)

*C. johnstoni* + *C. novaeguineae*: 31(0)

*C. johnstoni*: 19(1)

*C. novaeguineae*: 23(0), 28(0)

*C. niloticus* + New World *Crocodylus*: 3(1), 22(1)

*C. niloticus*: no autapomorphies

New world *Crocodylus*: 1(0), 15(1), 20(0), 21(2)

*C. falconensis*: no autapomorphies

*C. moreletii* + *C. rhombifer* + *C. acutus* + *C. intermedius*: 1(0), 21(2), 30(1), 31(1)

*C. moreletii*: no autapomorphies

*C. rhombifer*: 11(1), 24(1)

*C. acutus* + *C. intermedius*: 32(1)

*C. acutus*: no autapomorphies

*C. intermedius*: 13(1), 22(0)

### New caimanine species

The phylogenetic analysis including *Globidentosuchus brachyrostris* gen. et sp. nov. resulted in a total of 20160 most parsimonious trees (minimum length=650; Fig. 5b; Supplementary Figure S11). Note that character (97) for *Alligator thomsoni* (=althom in matrix file) in the original matrix of Brochu et al.<sup>64</sup> was incorrectly scored with "9" instead of "0" and character (156) was scored with (2) in *Piscogavialis jugaliperforatus* and *Gryposuchus colombianus*, although (0) or (1) should have been the only possible character states following the character description. Both taxa are scored with (1) herein based on personal observation of holotypes by one of us (DCF). The original score (0) for character (150) and (3) for character (158) in *Eocaiman cavernensis* (=eocai in matrix file) by Brochu et al.<sup>64</sup> were changed to (?), based on the poor preservation of that region of the skull in the holotype specimen.

The results of the TNT analysis could be verified by a second analysis using the heuristic search option in PAUP v. 4.0b10 for Microsoft Windows<sup>68</sup>. For the latter, a setting of MaxTrees=15000 was enforced as previous tries with an open, step-wise automated increase of the number of trees retained led to a critical termination of the analysis. The statistics of this analysis were: tree length = 650; consistency index (CI) = 0.3477; homoplasy index (HI) = 0.6523; CI excluding uninformative characters = 0.3426; HI excluding uninformative characters = 0.6574; retention index (RI) = 0.8110; rescaled consistency index (RC) = 0.2820. The strict consensus of the first 1000 MPTs shows exactly the same topology and tree length (650 steps) as in the TNT analysis.

Re-running the analysis after incorporating *Necrosuchus ionensis*<sup>69</sup> in the matrix basically recovered the same results as the previous analysis (tree length remained at 650; total number of MPTs = 24100), but with less resolution among basal caimanines (see Supplementary Figure S12). The previous sister group relationship between *Tsoabichi* and *Paleosuchus* was not recovered in this second run and the tree configuration with the polytomy among caimanines resembles that of the strict consensus shown in figure 9B in Brochu<sup>70</sup>. Following that previous work, we thus tentatively treat *Tsoabichi* as a caimanine herein as well.

Note that fundamental differences exist between the morphology-based matrices like the one from Brochu et al.<sup>64</sup> used herein and molecular analyses<sup>71-74</sup>, especially pertaining to the hotly debated relationship between true and false gharials and crocodylines. However, assuming that tomistomines (the material tentatively assigned to ?*Thecachamps*) are included in the

Crocodylidae as suggested by anatomy and the palaeontological record<sup>62</sup>, as well as developmental data<sup>75</sup>, it is possible to include the latter clade in the crocodilian fauna of Urumaco as well.

### Character codings

The following coding based on and modified from the matrix of Brochu et al.<sup>64</sup> was used (unknown or non-applicable characters were coded as question marks; the coding of *Necrosuchus ionensis* follows Brochu<sup>69</sup>):

#### *Bernissartia fragesii*

?????0???0111102100?00?0?000???0000?100010???0010?000???????10?0?00?001?1????0  
00?0?0000?00030?00?????1000?????1?0000?000??0100?0??000100?0?0?0?0?0010?0??00??  
0????????000?0000?000

#### *Allodaposuchus precedens*

??00010?  
000000123000000?100000???00000001010300011000101100???0100000001100010000??  
???1??01?010001?000

#### *Acynodon iberoccitanus*

??10104101???????0???????0?0?????00010  
?000000106000000?00100???0000000101?00???20000?0100?110?0000?010100000?1??  
???????1???0???010

#### *Acynodon adriaticus*

?????1?????????????01?100?1?????????010?10?????????01???????0???0??100?00?000  
10?000?0?1060000?0?????110????00?00011010000?1?11?0?0100???0???0?010?0?0010???  
???????????1???01?0

#### *Iharkutosuchus makadii*

??10124?????????110???00??10?1???0001  
??0000011061000?0???0110????0000001001100001201001?100?1?0?00?0???12???100?2??  
???1???1000000??110

#### *Hylaeochampsia vectiana*

??0?????0?????  
?????0?0?1000?00??0110?0?00000001001000?0?2110000120?????1?0?000010100000000???  
?1?001001000?0110

#### *Eothoracosaurus mississippiensis*

?????0????????????01?0000????????00?00?0???122???3?????0????00?011?0???001  
20?000?102500000?000000?000000101001000?00?000100?01???10000010?001?00  
???????100010000000

*Thoracosaurus neocesariensis*

?????0?????111?1?010????0011?0?0?00?0?0???1122???3???????10?000?01?0???00  
120?0000?1025000000?000000?0?00001010010000?00000000110?00010?1?0000100001  
00000000?00100?10000000

*Thoracosaurus macrorhynchus*

?????0???0?1111?1?01????00?0?0?00?0?0???1?22???3?????0?100000001100???00  
120?00?0?1025000000?000000?0?00001010010000110000000110?000100?10001010?001  
0000???0?0100010000000

*Eosuchus minor*

?????0???0?111???01?00?0?01???0000?000?0?0???1122??0300?0000?10?000001100???0  
0120?0000?1025?00000?000000?00000001010010000?10000000110???0100?10?10010000  
1?0100?1???101010101003

*Eosuchus lerichei*

?????0?????01????01???????1???????0???????1122???3?????????????????0????0012  
0?0000?1025000000?0000000?0000010100100000100000?0110?000?0??10?2001000010?1  
????????10?01?101003

*Eogavialis africanum*

????????1?????11???010?????????0?????????0???1122??03?????10?100000???1101???001  
20?000?01025?00000?0000000000000001010010000010000000121?000100?1001001000010  
100?000??0101010100000

*Piscogavialis jugaliperforatus*

????????????????????????????1????????????11?2???3?????0001???????10?????00120  
?001001025000000?000000?000000101001000000?000000111?1?0001010020010000100?  
0?1?0?0?12??1?10?000

*Gryposuchus colombianus*

???0?0???001?????01?0000?????????????0???11223?030100?000100000001100???00  
12010000?1025?00000?0?0000?0?00001010010000011000000121?000100?100110100001  
00000100?00121010100000

*Gavialis* sp. (Siwalik)



????????????????010????????????????????22???3?????0?100000??1?0?????00?3  
0?0?????2??0??0?0?0000??0?0000?0?00100?0?1??0000121?000100?100??0?000010000  
?????00121010100000

*Gavialis gangeticus*

020000000?001111011010000000111000000?0000000011223003000000001000000011000  
100001301000001025?0000000000000000000101001000001100000012100001000100110  
100001000000000000121010100000

*Borealosuchus threeensis*

????0????????????01??????0?????1?00??20??01002??1?????10?11?000001000??????  
??  
??????????????

*Borealosuchus formidabilis*

000?000?0?11001001001000000101000001?000?20??0110200000?000?110000000100001  
??00020?0000?0023100000?0000001000000010100100010100201?11000000?00?00001010  
0101000?????00100110000000

*Borealosuchus wilsoni*

?????0??????????1001000000101??00?1?000?20??01002??100?0?001100000201000????0  
0020?0?0??0231000?????00001?0?0?001010010001010020101100?000100??00110100101  
0000?00??010011?0?0000

*Borealosuchus acutidentatus*

????????????????????????0????????????????002????????????000?????0?????00020  
?0?00?0231000?????0000????0?0?0?0??????1?002?1?1100?0?0?0?0?011010?101000??  
????010??1?0?0000

*Borealosuchus sternbergii*

000000000?110010?1001000000101000001?00??0??011020000000?00010000000100000  
??00020?00000001310000001000001?0?00000111010001010000111100?000100?00000010  
0101000000?1?00100110000000

*Pristichampsus vorax*

????0?0??01001001?01?00000111??0100?10??1???1110?000?????0??1000001?1?0?????2  
1010?0000?0003000100?000000??0?00000010010001010000111110??0100?01000010010  
1000??01??11001100000002

*Pristichampsus geiseltalensis*

??????????0?0??01?000?0??1??0100?1???1???11102000?????0?1???0??1?1????21?  
20?0000000030001??000000??0000001001010??10000111110?0?0?00?0?010010?10100  
?????????1???10000002

*Planocrania hengdongensis*

????????????????????1????????????????????1110???1????????1???0?01?0????20010  
?0?????01300?????0?000????0???01001??????0??1?1100??????0?0?00100?0100?????  
1???1???10?10001

*Planocrania datangensis*

??11????0????????????????????20010?  
000??1003000000?0?000??????000?01??????0??1?1110??????0?000010010?0?0?????  
??????10??0?0?

*Leidyosuchus canadensis*

????0?0??????1????010000011?1??10?0?11??11???0110?00000?0?01?100000011101????  
0010?0000000030000000001000100010000111010001010000111100?01010010010001001  
0100000001?00100110010001

*Deinosuchus riograndensis*

?????0????????????01????????????????00???1???0110???001?0?11?10??0??11?0????00??  
1?0?????0?0000??0?00011?00?0????????????000111120?012210?1110001001?1000??  
000?0?????1??100?1

*Diplocynodon ratelii*

?????0?????000??010?00?1111001400?10??21???01002101????0111000001?1101????  
0120?0000001230000000101000??0?00000011110001010000111100??10100100000010110  
100000001?10100110010001

*Diplocynodon hantoniensis*

100???1?1?01000010001000011111??1400?101?21???011021010????011100000111101???  
?00120?0?000?11300?000?1010001?0?00000010110001010000111100?110100?001010101  
101000??0?1??010011?010001

*Diplocynodon muelleri*

????????????????????1?01??1????14?0?10??21???01002??2????01110??10011100????00  
120?1000001230000000101000???0000011111000001000?1?1100?110??0?01?010101101  
00????????0100110010001

*Diplocynodon tormis*

????????????????????1????1????????10??21??01?021?1????01?1?00????11?????0?12  
0??00000123000000?1010001??000000111100?0?10000111100?110100000101010110100  
?0???1?001?0110010001

*Diplocynodon darwini*

100001001?010000?00010000?1111??1400?101121??011020010??0?01?10000011110100?  
?00020?0000?0103000000?0?000?0?0000001111?00101000?111100?110100?0110101011  
01000??????0100110010001

*Baryphracta deponiae*

100?0?0??????0????01?0???1????14?0?10??21????1?02??0????01?10??0??1110?????00  
1???000??01030000?0????000?????0?0001?11000?01000?111100?110100?0??011?0?101?0  
0????????1???1??10001

*Brachychampsia montana*

101011001?1100??0001??000111100?000?103111???11101101????01110?00001110100?  
?00110?0002?1101000000?0010001?0?01000001111001012001111100?110200?011100101  
10102000101?00100110010001

*Brachychampsia sealeyi*

????????????????????????????????10???1???11101??0??????11?0000111?1???001?  
0?0002?110100000??010?????????00????????10?2001101?00??????????100???????2????  
????????1??10??1

*Stangerochampsia mccabei*

???110??010010?0001000001111001000?01??11???111010100????0111110000?110?????  
00110?0002?1102000000?001000??00000001111001012001111100?110200?0?11001021  
01000??1?1??0100110010001

*Ceratosuchus burdoshi*

????????????????????????????????0?1???????11111??0?????01?10??00?11?01???0001  
0?0?01?0102000000??1000?0?0??00??01???1?1??0?111100???????0???010?111?????  
????10??10010001

*Hassiacosuchus haupti*

001?1?0?1?????0??01?000?1111????0??11?11???111110?0?????01?10?0??11101????00  
010?00??010?0000????0001?0?????0????????1100?111100?1?0200?01120010210101?  
??????01???10010001

*Navajosuchus mooki*

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*Allognathosuchus polyodon*

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*Allognathosuchus wartheni*

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*Procaimanoidea kayi*

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*Procaimanoidea utahensis*

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*Arambourgia gaudryi*

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*Wannaganosuchus brachymanus*

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*Alligator sinensis*

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11001000010000102000000000100011001000000111100101101111110011020010112001  
0210101000111100100110010001

*Alligator mississippiensis*

101011001?01001000001011011111001100011210110011000112010010112000101111010  
01100100001000010200000000010001110000000011110010110111111001102001011210  
10210101000111100100110010001

*Alligator mefferdi*

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*Alligator thomsoni*

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*Alligator olseni*

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*Alligator mcgrewi*

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*Alligator prenasalis*

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*Eocaiman cavernensis*

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*Tsoabichi greenriverensis*

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*Purussaurus neivensis*

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0110?0001?0102000000?0010001?0?0?00000111101211111111110?110201?0112011?210  
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*Orthogenysuchus olsen*

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*Mourasuchus spp.*

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*Caiman yacare*

101111001?10001000001010111111001100011122111011002112101011101011020110010  
1110011000000001120000000010001100100000011110121111011111001102011011201  
11210103000101100100110210001

*Caiman crocodilus*

101111001?10001000001010111111001100011122111011002112101011101011020110010  
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11210103000101100100110210001

*Caiman latirostris*

101110001?10001000001010?111110011000111221210110021121010111?10110201100???  
11001100000000102001000000100011001000000111101211100111110011020110112111  
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*Caiman lutescens*

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*Melanosuchus fisheri*

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*Melanosuchus niger*

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110011000000001020010100001000110010000001111012111001111110011020110112111  
1210103000101100100110210001

*Paleosuchus trigonatus*

100111111?01001010001000111111211300011132112011002122211111111011000110010  
111101100001000102000000000100011000100010111101111000111111011102011011211  
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*Paleosuchus palpebrosus*

100111111?010010101010001111112113000111321120110021222111?11?10110001100?01  
111011000010001020000000001000110001000101111011110001111110111020110112111  
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*Mecistops cataphractus*

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001001200000010021000000010000011010000101101000101000011111000010111001200  
10010100011101011110010000003

*Crocodylus niloticus*

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001001100000010021000000110000011010010001101000101100011111000010111001200  
10010100011101011110011000003

*Crocodylus porosus*

111000001?00101010101110001111201200011120110111002101010001011000111010111  
001001100000010021000100110000011010010001101000101000011111000010111001200  
10010100011101011110011000003

*Crocodylus rhombifer*

001000001?10101000101110011111201100011120110111002101010001011000111010111  
001001100000010021010000110000011010010001101000101100011111000010111001200  
10011100011101011110011000003

*Euthecodon arambourgi*

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*Osteolaemus tetraspis*

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011010000010100210001000100000110110010111010101010000111110100101010012111  
0010110011101011110110000003

*Osteolaemus osborni*

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011011000010100210001000100000110110010010010101010000111110100101010012111  
0010110011101011110110000003

*Voay robustus*

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0110?0000?00210001000100000110100010111010101010000111110?00101110012011001  
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*Rimasuchus lloydi*

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*Crocodylus pigotti*

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*Crocodylus megarhinus*

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*Australosuchus clarkae*

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110?00001102100000001000001?0?000000???????1010000111110?002011?011200100101  
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*Kambara implexidens*

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110?00001102100000001000001?0100000010010001010000111110?002011?001200100101  
00011101?11110010000001

*Trilophosuchus rackhami*



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*Quinkana* spp.

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010102?11101?11??01?000???1

*Tomistoma schlegelii*

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001001200000011021000001010000011010001001001000101100011111000001101001210  
10010100011001011110010000003

*Tomistoma lusitanica*

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*Toyotamaphimeia machikanense*

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00120?00001100400000??00000??0000?010010000?10000011110??00?1??1??21010?10  
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*Gavialosuchus eggenburgensis*

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*Paratomistoma courti*

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?101?0?100??00?

*Tomistoma cairens*

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*Thecachampsia antiqua*

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00120?000011021000000?100000??0?0000101?010001011000011110??011??1012001001  
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*Tomistoma petrolica*

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*Dollosuchoides densmorei*

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0120?00?0?1021000000??00000??01?0101001000101100?011110??????1??20010?1010  
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*Kentisuchus spenceri*

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*Brachyuranochampsia eversolei*

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*Crocodylus acer*

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*Crocodylus depressifrons*

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00110?0000?1011000000?1100001?0?0001001?01000101?000111100?010200?0012001001  
0100011001?11100010000003

*Crocodylus affinis*

001001001?10001000011100001111001100?10??1??111021010100000110000000101100  
??00110?000010011000000?010000??0?00010011010001010000111100?0?010??00120010  
01010001??0??1100010000003

*Asiatosuchus germanicus*

001?0?0?1?001010?0101?000?1111??1??0?????1???11102000?????00110000??0101?00??  
00010?0000?000100000???10000??0?00010???01000101000?111100???0100?00111010010  
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*Prodiplocynodon langi*

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*Necrosuchus ionensis*

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***Globidentosuchus brachyrostris* gen. et sp. nov.**

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2??000??01?20000???1?10?0??????0???0?11?????1?1??1?1100??????0?0??2011??101?3??  
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## Supplementary References

- 54 Quiroz, L.I. & Jaramillo, C.A., Stratigraphy and sedimentary environments of Miocene shallow to marginal marine deposits in the Urumaco Trough, Falcón Basin, western Venezuela in *Urumaco and Venezuelan Palaeontology – The Fossil Record of the Northern Neotropics*, (eds. M. R. Sánchez-Villagra, O. A. Aguilera, & A. A. Carlini) 153-172 (Indiana University Press, Bloomington, 2010).
- 55 Brochu, C.A. Crocodylian snouts in space and time: phylogenetic approaches toward adaptive radiation. *Am. Zool.* **41**, 564-585 (2001).
- 56 Sereno, P.C., Larsson, H.C.E., Sidor, C.A., & Gado, B. The giant crocodyliform *Sarcosuchus* from the Cretaceous of Africa. *Science* **294**, 1516-1519 (2001).
- 57 Platt, S.G. *et al.* Size estimation, morphometrics, sex ratio, sexual size dimorphism, and biomass of Morelet's crocodile in northern Belize. *Caribb. J. Sci.* **45**, 80-93 (2009).
- 58 Platt, S.G., Rainwater, T.R., Thorbjarnarson, J.B., & Martin, D. Size estimation, morphometrics, sex ratio, sexual size dimorphism, and biomass of *Crocodylus acutus* in the coastal zone of Belize. *Salamandra* **47**, 179-192 (2011).
- 59 Hurlburt, G.R., Heckert, A.B., & Farlow, J.O. Body mass estimates of phytosaurs (Archosauria: Parasuchidae) from the Petrified Forest Formation (Chinle Group: Revueltian) based on skull and limb bone measurements. *New Mexico Mus. Nat. Hist. Sci. Bull.* **24**, 105-114 (2003).
- 60 Webb, G.J.W. & Messel, H. Morphometric analysis of *Crocodylus porosus* from the north coast of Arnhem Land, northern Australia. *Austr. J. Zool.* **26**, 1-27 (1978).
- 61 Vucetich, M.G., Carlini, A.A., Aguilera, O., & Sánchez-Villagra, M.R. The Tropics as reservoir of otherwise extinct mammals: the case of rodents from a new Pliocene faunal assemblage from northern Venezuela. *J. Mammal. Evol.* **17**, 265-273 (2010).
- 62 Brochu, C.A., Njau, J., Blumenschine, R.J., & Densmore, L.D., A new horned crocodile from the Plio-Pleistocene hominid sites at Olduvai Gorge, Tanzania. *PLoS ONE* **5**(2), e9333. doi:10.1371/journal.pone.0009333 (2010).
- 63 Buscalioni, A.D., Sanz, J.L., & Casanovas, M.L. A new species of the eusuchian crocodile *Diplocynodon* from the Eocene of Spain. *N. Jb. Geol. Pal., Abh.* **187**, 1-29 (1992).

- 64 Brochu, C.A., Parris, D.C., Grandstaff, B.S., Denton Jr., R.K., & Gallagher, W.B. A new species of *Borealosuchus* (Crocodyliformes, Eusuchia) from the Late Cretaceous–early Paleogene of New Jersey. *J. Vertebr. Paleontol.* **32**, 105-116 (2012).
- 65 Norell, M.A. The higher level relationships of the extant Crocodylia. *J. Herpetol.* **23**, 325-335 (1989).
- 66 Norell, M.A. *Cladistic approaches to paleobiology as applied to the phylogeny of alligatorids*. (PhD Thesis, Yale University, New Haven, CT, 1988).
- 67 Brochu, C.A. Phylogeny, systematics, and historical biogeography of Alligatoroidea. *Soc. Vertebr. Paleontol. Memoir* **6**, 9-100 (1999).
- 68 Swofford, D.L. *PAUP\*. Phylogenetic analysis using parsimony (\*and other methods). Version 4*. (Sinauer Associates, Sunderland, Massachusetts, 2002).
- 69 Brochu, C. A. Phylogenetic relationships of *Necrosuchus ionensis* Simpson, 1937 and the early history of caimanines. *Zool. J. Linnean Soc.* **163**, S228-S256 (2011).
- 70 Brochu, C.A. A new alligatorid from the lower Eocene Green River Formation of Wyoming and the origin of caimans. *J. Vertebr. Paleontol.* **30**, 1109-1126 (2010).
- 71 Harshman, J., Huddleston, C.J., Bollback, J., Parsons, T.J., & Braun, M.J. True and false gharials: a nuclear gene phylogeny of Crocodylia. *Syst. Biol.* **52**, 386-402 (2003).
- 72 Oaks, J.R. A time-calibrated species tree of Crocodylia reveals a recent radiation of the true crocodiles. *Evolution* **65**, 3285-3297 (2011).
- 73 Meganathan, P.R., Dubey, B., Batzer, M.A., Ray, D.A., & Haque, I. Molecular phylogenetic analyses of genus *Crocodylus* (Eusuchia, Crocodylia, Crocodylidae) and the taxonomic position of *Crocodylus porosus*. *Mol. Phylog. Evol.* **57**, 393-402 (2010).
- 74 McAliley, L.R. *et al.* Are crocodiles really monophyletic?-Evidence for subdivisions from sequence and morphological data. *Mol. Phylog. Evol.* **39**, 16-32 (2006).
- 75 Piras, P. *et al.* The *Gavialis–Tomistoma* debate: the contribution of skull ontogenetic allometry and growth trajectories to the study of crocodylian relationships. *Evol. Dev.* **12**, 568-579 (2010).